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Spectral and Temporal Properties of MAXI J1836-194 during 2011 Outburst

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Abstract. We study black hole candidate (BHC) MAXI J1836-194 during its 2011 outburst with Two Component Advective Flow (TCAF) model using RXTE/PCU2 data in 2.5 − 25 keV band. From spectral fit, accretion flow parameters such as Keplerian disk rate ($\dot{m}_d$), sub-Keplerian halo rate ($\dot{m}_h$), shock location (X_s) and compression ratio (R) are extracted directly. During the entire phase of the outburst, quasi-periodic oscillations (QPOs) are observed sporadically. From the nature of the variation of accretion rate ratio (ARR=$\dot{m}_h$ / $\dot{m}_d$) and QPOs, entire period of the outburst is classified in two spectral states, such as, hard (HS), hard-intermediate (HIMS). Unlike other transient BHCs, no signature of soft (SS) and soft-intermediate (SIMS) spectral states are observed during entire phase of the outburst.

Keywords : Black Holes, accretion disks, Stars: (MAXI J1836-194)

1. Introduction

The transient BHC MAXI J1836-194 was discovered simultaneously by MAXI/GSC and SWIFT/BAT on 2011 Aug. 29 at sky location of R.A. = $18^h35^m43.43^s$, Dec = $-19°19'12.1''$. This is a short orbital period (< 4.9 hrs.) and highly rotating BHC (spin parameter $a = 0.88 \pm 0.03$) with mass and distance are predicted in the range of $4-12\ M_\odot$, $4-10$ kpc respectively (see, Jana et al., 2016 for references). Recently after the inclusion of TCAF model (Chakrabarti & Titarchuk, 1995) into NASA's spectral analysis software package XSPEC as an additive table model, accretion flow dynamics of few BHCs (GX 339-4, H 1743-322, MAXI J1659-152) are well understood (see, Debnath et al., 2014, 2015a,b; Mondal et al., 2014). This motivated us to study current outburst of MAXI J1836-194 with the model (see, Jana et al., 2016).

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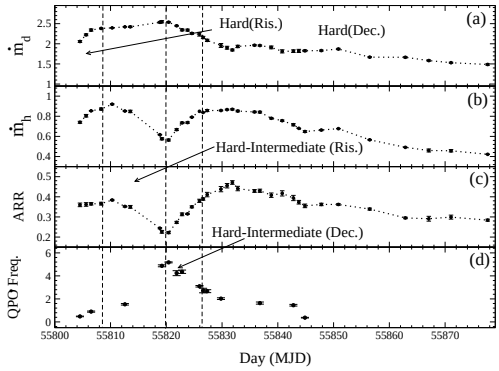

Figure 1. Variations of TCAF fitted/derived (a) Keplerian disk ($\dot{m}_d$) rate, (b) sub-Keplerian halo ($\dot{m}_h$) rate, (c) ARR ($\dot{m}_h/\dot{m}_d$), and (d) observed QPO frequency with day (MJD) are shown.

2. Result and Discussion

We analyze RXTE/PCA data for 35 observations, spread over entire 2011 outburst. 2.5 – 25 keV PCU2 spectra are fitted with TCAF in XSPEC to extract physical flow parameters, such as, $\dot{m}_d$ in Eddington rate, $\dot{m}_h$ in Eddington rate, X_s in Schwarzschild radius and R. Based on the variation of ARR and nature of QPOs, entire phase of the 2011 outburst of MAXI J1836-194 is classified in the following sequence: HS (ris) → HIMS (ris) → HIMS (dec) → HS (dec). During the first five observations, the BHC was in hard state with clear dominance in $\dot{m}_h$. On 2011 Sept 6 (MJD=55810.29), ARR attains maximum as we observe a transition from HS to HIMS (ris). On Sept 16 (MJD=55820.41), the BHC enters in HIMS (dec), when highest QPO frequency of 5.17 Hz is observed. On 2011 Sept 27 (MJD=55831.85) ARR reaches its maximum value (with the maxima in $\dot{m}_h$) and the source enters into the HS (dec). Strangely SS and SIMS are missing during the entire phase of the outburst. The reason behind this may be, the BH is immersed into the excretion disk of a high massive companion Be star. We do not find QPOs on regular basis, although trends of monotonically increasing (0.47-5.17 Hz) and decreasing (5.17-0.37 Hz) nature of QPO frequencies are observed during rising and declining phases respectively of the outburst (Fig. 1d). This is may be due to non-satisfaction of resonance condition between cooling and infall time scales (Chakrabarti et al., 2015; Mondal et al., 2015).

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